9479.

PATENT SPECIFICATION (11) 1 595 961

(21) Application No. 1837/77 (22) Filed 18 Jan. 1977 (19)

(23) Complete Specification filed 17 Jan. 1978

(44) Complete Specification published 19 Aug. 1981

(51) INT. CL.³ F28D 15/00

(52) Index at acceptance

F4U 25A 25B

F4S X2

1 595 961

(72) Inventor MICHAEL KENNETH WALKER

(54) COOLING ELECTRICAL EQUIPMENT

(71) We, THORN AUTOMATION LIMITED, a British Company of Beech Avenue, New Basford, Nottingham do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which is is to be performed, to be particularly described in and by the following statement:—

This invention relates to cooled modules, especially but not exclusively, modules containing electrical equipment, for example, electronic or electro-mechanical equipment.

In the past modules of electronic or electro-mechanical equipment have been mounted in racks or other suitable support means and in certain circumstances problems have arisen as a result of the build-up of heat which can arise while the equipment is in use.

It is an object of the present invention to obviate or mitigate this problem.

According to the present invention there is provided a module having a casing the contents of which have to be cooled, comprising first heat transfer means arranged within the casing separately from components therein and second heat transfer means outside the casing and at least one heat pipe extending between said first and second heat transfer means, the heat pipe being arranged to permit transfer of heat from the first to the second heat transfer means only.

A heat pipe is a sealed tube containing a small amount of liquid in equilibrium with its saturated vapour and a wick. When one end of the tube is heated the liquid therein evaporates and the excess vapour created is condensed at the other end of the pipe which is cooler. Thus fluid carries the heat, as a latent heat, from the heated end to the cooled end. The condensed liquid is recirculated from the cooled end to the heated end by the capillary action of the wick and/or by gravity.

Preferably said first and/or said second heat transfer means comprise finned surfaces.

Preferably cooling fluid is forced over said first and/or said second heat transfer means.

Preferably said first heat transfer means are enclosed in a passage through which fluid to be cooled is passed, a fan being provided to give this forced circulation.

The or each heat pipe may be arranged at an angle to the vertical, the upper end being located in the second heat transfer means and the wick terminating at or near the point at which the heat pipe leaves the first heat transfer means.

Preferably at least the first heat transfer means is formed by two heat transfer members each having outstanding fins formed integrally therewith the planar surfaces of the members opposite said fins being arranged in abuting relationship and channels being formed in each of said planar surfaces whereby said heat pipe can be accommodated in the passage formed by the channels on abutment of the members.

In an alternative embodiment the or each heat pipe is arranged vertically with the second heat transfer means above the first heat transfer means, the second heat transfer means comprising fins formed on the or each individual heat pipe.

The casing of the module may be of double thickness and the fluid for removing heat from the second heat transfer means may be passed through the cavity between the double walls of the casing.

Embodiments of the present invention will now be described by way of example only, with reference to the accompanying drawings in which:—

Fig. 1 shows a perspective view of a module containing electronic components;

Figs. 2, 3 and 4 show respectively, top, side and bottom sectional views of a module similar to that shown in Fig. 1 but including some modifications;

Fig. 5 shows a detail of a module of the type shown in Fig. 1; and

Fig. 6 shows a perspective view of another modified module, with the upper end of a heat tube thereof illustrated in detail.

An enclosed module comprising a caing 10 containing electronic equipment (not shown)

is provided at its rear with a heat conducting plate 12 to which is attached a finned first heat exchange member 14, the member 14 being cast from some suitable alloy and having attachment means (not shown) for fixing it to the plate 12. A second finned heat exchange member 16 is attached to the rear of the plate 12 on the outside of the module casing 10, the fins of this second heat exchange member 16 and those of the first heat exchange member 14 running substantially vertically, whereby vertical gas passages are provided between the fins of each member.

Thus in operation, air within the module which has been heated by heat generated in the electronic components circulates within the module casing which is hermetically sealed, and circulating air passes between the fins of the first heat exchange member 14. The heat absorbed by the heat exchange member 14 is transferred by conduction to the second heat exchange member 16 which in turn is cooled by forcing a draft of cooling air between the fins.

The heat exchange between the first and second heat exchange members is considerably improved by introducing a plurality of heat pipes 18, only one of which is shown, extending between the members.

Figs. 2—4 show a modified module in which the first heat exchange member 14 is incorporated in a duct 20 at the rear of the module casing. The first heat exchange member 14 comprises two finned castings arranged with their non-finned surfaces in abuting relationship and vertically orientated. The length of the first heat exchange member 14 is such that chambers are defined in the duct 20 at the top and bottom thereof and the width of the first member from fin-tip to fin-tip is such that the member occupies the entire transverse width of the duct, as best seen from Figs. 2 to 4.

A forced circulation of the clean air within the module casing is achieved by means of an electrically driven fan 22 arranged at the bottom of the duct 20.

The back-to-back arrangement of the members forming the first heat exchange member is advantageous in that it is a simple matter to machine channels in the abuting faces of the members which, on placing the members together, form passages which accommodate the heat pipes.

It will be realised that the second heat exchange member 16 can be manufactured from two components in a similar manner.

In normal operating conditions the interior of the module casing is at a higher temperature than its surroundings and thus heat flow is outwards from the first to the second heat exchanger member. In certain circumstances, however, for example where the ambient temperature is particularly high the flow of heat could be from the second heat exchange member to the first and the thus increased temperature within the module casing could damage the electronic components.

Thus the heat pipes are arranged such that they operate in one "direction" only; in other words, they only allow the flow of heat from the first to the second heat exchange member. To achieve this the heat pipes 18 are arranged, as shown in Fig. 5, at an angle to the horizontal with the lower end accommodated in the first heat exchange member. Furthermore the wick 26 within the heat pipe does not extend for the entire length thereof but extends only over the length of the heat pipe accommodated within the first heat exchange member 14.

Thus, in operation, when the internal temperature of the module casing is greater than the external temperature, liquid within the heat pipe will evaporate and transfer heat to the upper end of the pipe encased within the second heat exchange member. The vapour will then recondense and, by gravity, the condensate will return on to the wick area which will then transfer the liquid by capillary action and gravity to the bottom of the heat pipe, thus forming a closed circuit. If, on the other hand, the external temperature is greater than the internal temperature of the module casing, when heat is applied to the upper end of the heat pipe, because the wick does not extend to this upper end the closed loop has been "open-circuited" so that there is no liquid available for evaporation and transfer of latent heat, and thus heat is not transferred to the interior of the module casing except by normal conduction. It can be arranged that the heat transfer by normal conduction is minimised so that it does not have detrimental effects on the electronics within the module casing.

In a modified embodiment shown in Fig. 6, the first heat transfer member 14, which again comprises a finned casting, is arranged along the top of the module casing which is double walled, having an internal wall 28 and an external wall 30 providing a cavity therebetween. The external wall 30 is provided with an inlet 32 to admit cooling air to the cavity which has an enlarged depth at the top thereof to accommodate the upper ends of one-way heat pipes 18 which are embedded in the first heat exchange member 14. The upper ends of the heat pipes 18 may be embedded in a further finned heat exchange member (not shown in Fig. 6) or, as as illustrated in Fig. 6, are provided with a plurality of disc-like cooling fins 34. Outlet apertures 36 for the cooling air are provided in the top of the outer casing 30 of the module casing. If desired, baffles 38 may be provided in the cavity defined by the walls 28 and 30 of the module casing.

Various modifications can be made without departing from the scope of the invention, for example, the cooling fluid for the second heat exchanger member may comprise a liquid forced over the cooling fins. Further as the module casing is sealed any suitable gas, for example, an inert gas, may be used to fill the casing.

The embodiments described above are particularly useful in aircraft applications in that there is no mechanical contact between printed circuit boards of the electronic components and the cooling fluid, the air or gas which is in direct contact with the electronic components is clean, the entire module can be readily removed for servicing and maintenance, and no moving parts are necessary to enhance heat transfer between the first and second members.

WHAT WE CLAIM IS:—

1. A module having a casing the contents of which have to be cooled, comprising first heat transfer means arranged within the casing separately from the components therein and second heat transfer means outside the casing and at least one heat pipe extending between said first and second heat transfer means, the heat pipe being arranged to permit transfer of heat from the first to the second heat transfer means only.

2. A module as claimed in claim 1, in which said first and/or said second heat transfer means comprise finned surfaces.

3. A module as claimed in claim 1 or claim 2, in which means are provided for forcing cooling fluid over said first and/or said second heat transfer means.

4. A module as claimed in any one of claims 1 to 3, in which said first heat transfer means are arranged in a passage through which, in use, fluid to be cooled is passed.

5. A module as claimed in claim 4, in which a fan is provided to assist the passage of fluid to be cooled over said first heat transfer means.

6. A module as claimed in any one of the preceding claims, in which the or each heat pipe is arranged at an angle to the horizontal, the upper end being located in the second heat transfer means and the wick of the heat pipe terminating at or near the point at which the heat pipe leaves the first heat transfer means.

7. A module as claimed in any one of the preceding claims, in which at least the first heat transfer means is formed by two heat transfer members each having outstanding fins formed integrally therewith, planar surfaces of the members opposite said fins being arranged in abutting relationship and channels being formed in each of said planar surfaces whereby the or each heat pipe is accommodated in a passage formed by the channels on abutment of the members.

8. A module as claimed in any of claims 1 to 6, in which a plurality of heat pipes are arranged vertically with the second heat transfer means above the first heat transfer means, the second heat transfer means comprising fins formed on each individual heat pipe.

9. A module as claimed in any one of the preceding claims in which the casing is provided with double walls, means being provided for causing a flow of fluid for removing heat from the second heat transfer means to pass through the cavity between the said walls.

10. A module substantially as hereinbefore described with reference to Figs. and 5, Figs. 2 to 4 or Fig. 6 of the accompanying drawings.

SWINDELL & PEARSON,
Chartered Patent Agents,
44 Friar Gate,
Derby DE1 1DA.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1981.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.

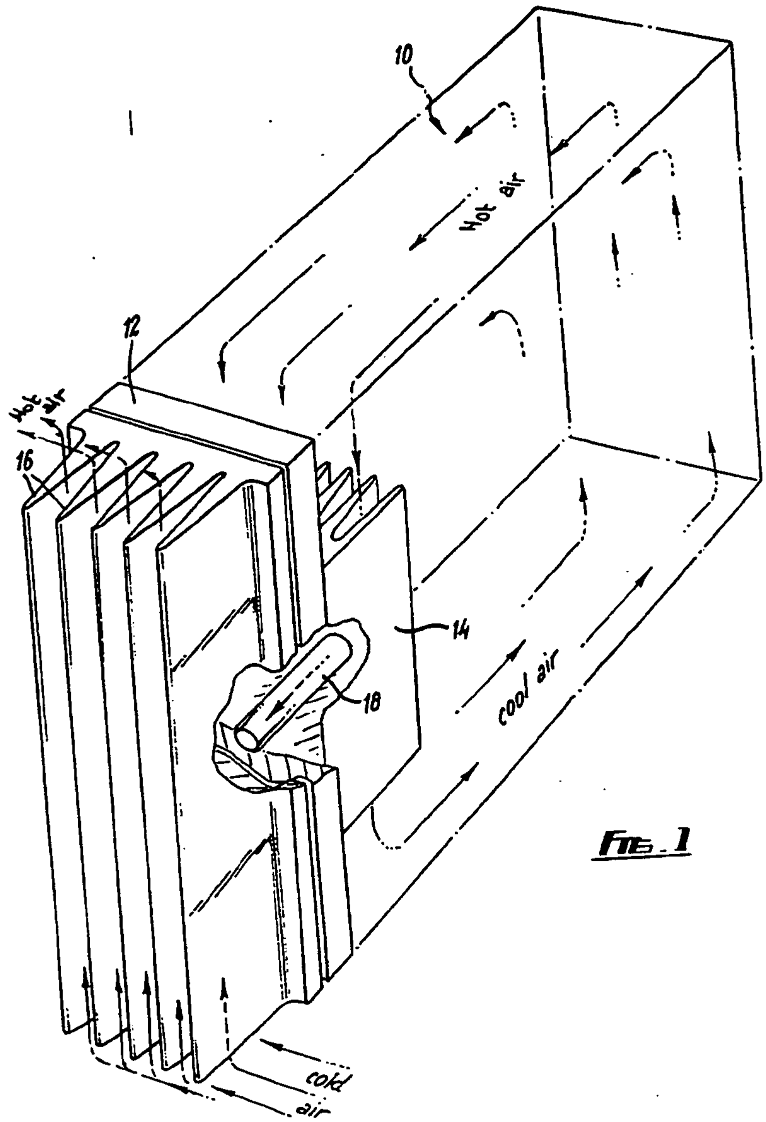

FIG. 1

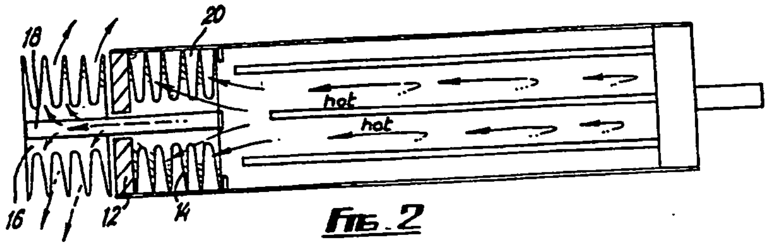

Fig. 2

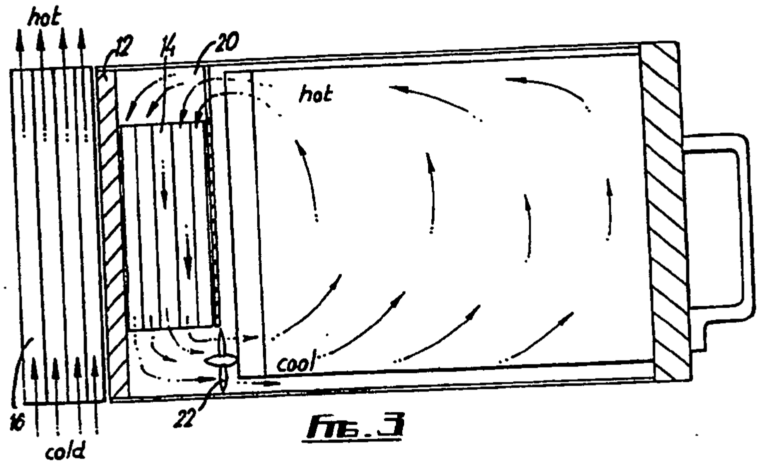

Fig. 3

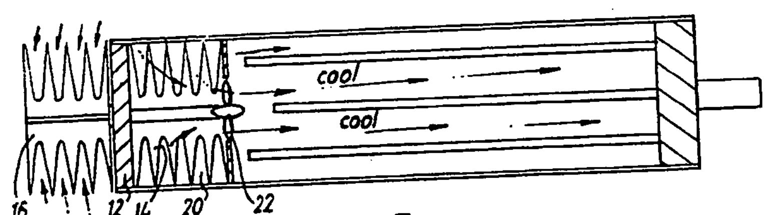

Fig. 4

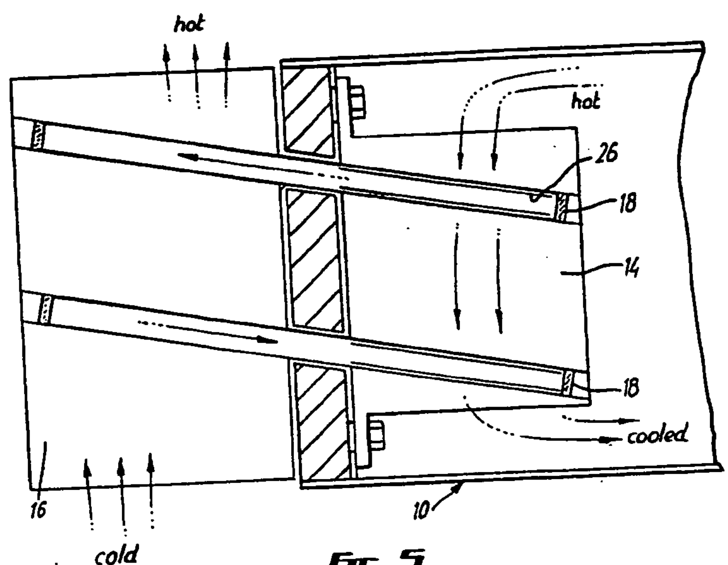

FIG. 5

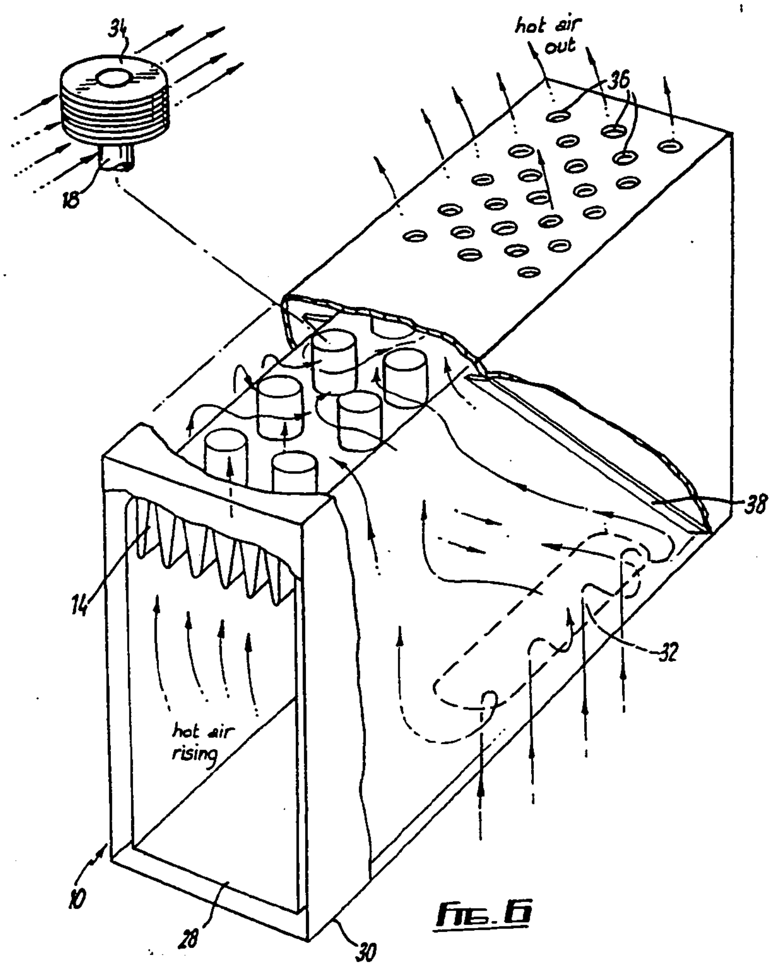

FIG. 6